SECTION 22 63 00
GAS SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Central Laboratory and Healthcare Gas Systems: Consisting of compressed air services; complete, ready for operation, including all necessary piping, fittings, valves, cabinets, station outlets, rough-ins, ceiling services, gages, alarms including low voltage wiring, nitrogen control panels, cylinder manifolds, air compressors, electric motors and starters, air dryers, filters, pressure regulators, dew point monitor, carbon monoxide monitor and all necessary parts, accessories, connections and equipment. G. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 07 84 00, FIRESTOPPING: Sealing around pipe penetrations to maintain the integrity of time rated construction.

D. Section 07 92 00, JOINT SEALANTS: Sealing around pipe penetrations through the floor to prevent moisture migration.

E. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: General requirements and items common to more than one section of Division 22.

F. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT: Electric motors.

G. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS: Requirements for commissioning, systems readiness checklist, and training.

H. SECTION 22 62 00, VACUUM SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES: Vacuum Piping and Equipment.

I. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Control wiring.

J. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit.

K. Section 26 27 26, WIRING DEVICES: Electrical wiring and accessories.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. American Society of Mechanical Engineers (ASME):

A13.1-2007 (R2013).....Scheme for the Identification of Piping Systems

B16.15-2013.....Cast Copper Alloy Threaded Fittings: Classes 125 and 250

B16.22-2013.....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.50-2013.....Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings

B40.100-2013.....Pressure Gauges and Gauge Attachments

ASME Boiler and Pressure Vessel Code -

BPVC Section VIII-2015..Rules for Construction of Pressure Vessels, Division I

BPVC Section IX-2015....Welding, Brazing, and Fusing Qualifications

C. American Society of Sanitary Engineers (ASSE):

6000 Series-2012.....Professional Qualifications Standard for Medical Gas Systems Personnel

D. American Society for Testing and Materials (ASTM):

B43-2014.....Standard Specification for Seamless Red Brass Pipe, Standard Sizes

B687-1999 (2011).....Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

B819-2000 (R2011).....Standard Specification for Seamless Copper Tube for Medical Gas Systems

D1785-2012.....Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

E. American Welding Society (AWS):

A5.8M/A5.8-2011.....Specification for Filler Metals for Brazing and Braze Welding

B2.2/B2.2M-2010.....Specification for Brazing Procedure and Performance Qualification

F. Compressed Gas Association (CGA):

C-9-2013.....Standard Color Marking of Compressed Gas Containers for Medical Use

G-4.1-2009.....Cleaning Equipment for Oxygen Service

G-10.1-2008.....Commodity Specification for Nitrogen

P-9-2008.....The Inert Gases: Argon, Nitrogen, and Helium

V-1-2013.....Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections

G. Manufacturing Standardization Society (MSS):

SP-72-2010a.....Ball Valves With Flanged or Butt-Welding Ends For General Service

SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

H. National Electrical Manufacturers Association (NEMA):

ICS 6-1993 (R2001, R2006) Industrial Control and Systems Enclosures

I. National Fire Protection Association (NFPA):

99-2015.....Health Care Facilities Code

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 63 00, GAS SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Piping.
2. Valves.
5. Gages.
8. Alarm controls and panels.
9. Pressure Switches.
12. Air compressor systems (Provide certified compressor test data at startup.):
    a. Compressors: Manufacturer and model.
    b. Characteristic performance curves.
    c. Compressor operating speed (RPM).
    d. Capacity: Free air delivered at indicated pressure (L/s) (SCFM).
    e. Type of bearing in compressor.
    f. Type of lubrication.
    g. Type and adjustment of drive.
    h. Electric motors: Manufacturer, frame and type.
    i. Speed of motors (RPM).

j. Current characteristics and horsepower of motors.

k. Receiver capacity and rating.

l. Air silencer: Manufacturer, type and model.

m. Air filters: Manufacturer, type, model and capacity.

n. Pressure regulators: Manufacturer and capacity.

o. Dew point monitor: Manufacturer, type and model.

p. Air dryers: Manufacturer, type, model and capacity (L/s) (SCFM).

q. Carbon monoxide monitor manufacturer, type and model.

r. Aftercoolers.

D. Certification: The completed systems have been installed, tested, purged, analyzed and verified in accordance with the requirements of this specification. Certification shall be submitted to COR.

E. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

A. Materials and Installation: In accordance with NFPA 99 and as specified.

B. Equipment Installer: Show technical qualifications and previous experience in installing laboratory and healthcare equipment on three similar projects. Submit names, phone numbers, and addresses of referenced projects. Installers shall meet the qualifications of ASSE Standard Series 6000.

C. Equipment Supplier: Provide evidence of equivalent product installed at three installations similar to this project that has been in satisfactory and efficient operation for three years. Submit names, phone numbers, and addresses where the product is installed.

D. Laboratory and healthcare System Testing Organization: The testing shall be conducted by a party technically competent and experienced in the field of laboratory and healthcare pipeline testing. Testing and systems verification shall be performed by personnel meeting the qualifications of ASSE Standard Series 6000. Such testing shall be performed by a party other than the installing contractor.

E. Provide the names of three projects where testing of medical or laboratory gases systems has been performed by the testing agency. Include the name of the project, names of such persons at that project who supervised the work for the project owner, or who accepted the report for the project owner, and a written statement that the projects

listed required work of similar scope to that set forth in this specification.

F. Submit the testing agency's detailed procedure which shall be followed in the testing of this project. Include details of the testing sequence, procedures for cross connection tests, outlet function tests, alarm tests, purity tests, etc., as required by this specification. For purity test procedures, include data on test methods, types of equipment to be used, calibration sources and method references.

G. Certification: Provide COR documentation 10 working days prior to submitting request for final inspection to include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits allowed by this specification.

H. "Hot taps" are prohibited for operating medical oxygen systems. Methods for connection and extension of active and pressurized medical gas systems without subsequent medical gas testing and verification are prohibited.

I. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on compact disc or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer,

model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.

D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

A. Copper Tubing: Type "K", ASTM B819, seamless copper tube, hard drawn temper, with wrought copper fittings conforming to ASME B16.22 or brazing fittings complying with ASME B16.50. Size designated reflecting nominal inside diameter. All tubing and fittings shall be labeled "ACR/OXY", "OXY", "OXY/MED", "ACR/MED", or "MED".

B. Brazing Alloy: AWS A5.8M/A5.8, Classification BCuP, greater than 538 degrees C (1000 degrees F) melting temperature. Flux is strictly prohibited for copper-to-copper connections.

C. Threaded Joints: Polytetrafluoroethylene (Teflon) tape.

D. Underground Protective Pipe: Polyvinyl Chloride (PVC), ASTM D1785, Schedule 80.

E. Memory metal couplings: Temperature and pressure rating shall not be less than that of a brazed joint in accordance with NFPA 99, paragraph 5.1.10.6.1.

F. Apply piping identification labels at the time of installation in accordance with NFPA 99. Apply supplementary color identification in accordance with CGA Pamphlet C-9.

G. Special Fittings: The following special fittings shall be permitted to be used in lieu of brazed joints:

1. Memory-metal couplings having temperature and pressure ratings joints not less than that of a brazed joint.
2. Listed or approved metallic gas tube fittings that, when made up, provide a permanent joint having the mechanical, thermal, and sealing integrity of a brazed joint.
3. Dielectric fittings where required by the manufacturer of special medical equipment to electrically isolate the equipment from the piping distribution system.
4. Axially swaged, elastic strain preload fittings providing metal to metal seal having pressure and temperature ratings not less than that of a brazed joint and when complete are permanent and non-separable.

2.3 VALVES

A. Ball: In-line, other than zone valves in cabinets:

1. 75 mm (3 inches) and smaller: Bronze/ brass body, MSS SP-72, MSS SP-110, Type II, Class 150, Style 1, with tubing extensions for brazed connections, full port, three-piece or double union end connections, Teflon seat seals, full flow, 4138 kPa (600 psig) WOG minimum working pressure, with locking type handle, cleaned for oxygen use and labeled for intended service.
2. 75 to 100 mm (3 to 4 inches): Bronze/ brass body, MSS SP-72 MSS SP-110, Type II, Class 150, Style 1 with tubing extensions brazed to flanges, full port, three piece, double seal, Teflon seals, full flow, 4138 kPa (600 psig) WOG minimum working pressure, with locking type handle, cleaned for oxygen use and labeled for intended service.

B. Check:

1. 75 mm (3 inches) and smaller: Bronze/brass body, straight through design for minimum pressure drop, spring loaded, self-aligning with Teflon cone seat, vibration free, silent operation, supplied NPT female threads at each end with flow direction arrow permanently cast into, cleaned for oxygen use and labeled for intended service, 2758 kPa (400 psig) WOG minimum working pressure.
2. 100 mm (4 inches) and larger: Iron body, bronze trim, swing type, vertical or horizontal installation, flange connection, with flow direction arrow permanently cast into, cleaned for oxygen use and labeled for intended service, 1035 kPa (150 psig) WSP.

2.4 GAGES

A. Pressure Gages: Includes gages temporarily supplied for testing purposes.

1. For line pressure use adjacent to source equipment: ASME B40.1, pressure gage, single, size 115 mm (4-1/2 inches), for compressed air, nitrogen and oxygen, accurate to within 2 percent, with metal case. Range shall be two times operating pressure. Dial graduations and figures shall be black on a white background, or white on a black background. Gage shall be cleaned for oxygen use, labeled for appropriate service, and marked "USE NO OIL". Install with gage cock.
2. For all services downstream of main shutoff valve: Manufactured for oxygen use, labeled for the appropriate service and marked "USE NO OIL", 40 mm (1-1/2 inch) diameter gage with dial range 1 to 690 kPa (1 to 100 psig) for air service .

2.10 ALARMS

A. Provide all low voltage control wiring, including wiring from alarm relay interface control cabinet to BAS, required for complete, proper functioning system, in conformance with Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Run wiring in conduit, in conformance with Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

B. Local Alarm Functions: Provide individual local air compressor malfunction alarms at each compressor system main control panel.

1. Compressor Malfunction Alarm: Each compressor system receiving any of the following individual signals and sends a single combined "compressor malfunction alarm" signal to master alarm panel.
   a. Thermal Malfunction Alarm: Functions when discharge air temperature exceeds 177 degrees C (350 degrees F), shutting down affected compressor.
   b. Lead Compressor Fails to Start: Functions when lead compressor fails to start when actuated, causing lag pump to start.
   c. Lag Compressor In Use: Functions when the primary or lead compressor is incapable of satisfying the demand. When three or more compressors are part of the system, the lag compressor in use alarm shall energize when the last compressor has been signaled to start.
   d. High Water Level in Receiver (liquid ring or water-cooled units).
   e. High Water Level in Separator (if so required) (liquid ring unit).
2. Desiccant Air Dryer Malfunction Alarm: Dryer receives the following individual signals and sends a single consolidated dryer malfunction alarm signal to master alarm panel.
   a. Dew Point Alarm: Functions when line pressure dew point rises above 4 degrees C (40 degrees F) at 380 kPa (55 psig).
3. Vacuum Pump Malfunction Alarm: Pump system receives the following individual signals and sends a single consolidated pump malfunction alarm signal to master alarm panel.
   a. High Temperature Shut down Alarm: Functions when exhaust air temperature exceeds 104 degrees C (220 degrees F), shutting down affected pump.
   b. Lead Pump Fails to Start Alarm: Functions when lead pump fails to start when actuated causing lag pump to start.
   c. Lag Pump In Use Alarm: Functions when the primary or lead vacuum pump in incapable of satisfying the demand. When three or more vacuum pumps are part of the system, the lag pump in use alarm shall energize when the last vacuum pump has been signaled to start.
5. Instrument Air Dew Point High: Functions when the line pressure dew point is greater than -30 degrees C (-22 degrees F).

5. Compressed Air Alarms:
   a. Medical air dew point high alarm: Functions when the line pressure dew point rises above 2 degrees C (35 degrees F) at 380 kPa (55 psig).
   b. Carbon Monoxide Alarm: Functions when the carbon monoxide levels rise above 10 parts per million; receives signal from the carbon monoxide monitor.
   c. Main Bank Filter Set Alarm: Functions when the pressure drop across filter set increases more than 14 kPa (2 psig) over that when filters are clean and new; operates by differential pressure switch or transmitters.
   d. Desiccant Prefilter Alarm: Functions when pressure across the filter increases more than 21 kPa (3 psig) over that when filters are clean and new; operates by pressure differential switch.
   e. Desiccant Post Filter Alarm: Functions when pressure drop across filter increases more than 21 kPa (3 psig) over that when filters are clean and new; operates by pressure differential switch.
   f. Desiccant Dryer Malfunction Alarm: Functions on any combination of failure of tower cycling and/or pressure dew point rise above 60 degrees C at 690 kPa (140 degrees F at 100 psig).
   g. Aftercooler High temperature Alarm: Functions when aftercooler discharge air temperature exceeds 38 degrees C (100 degrees F).
   h. Pressure Abnormal Alarm: Functions when system pressure downstream of main shutoff valve drops below 550 kPa (80 psig) (± gage or increases above 830 kPa (120 psig) (±14 kPa (±2 psig) set points; operated by pressure switch.
   i. Compressor Malfunction Alarm: Functions when compressor system control panel signals compressor thermal malfunction alarm, lead compressor fails to start alarm or high water level in receiver or separator (if so required) receives signal from system control panel.
   j. Low Lubricant Shutdown: For rotary screw compressors. Functions when lubricant level drops to a low point. Receives signal from compressor control panel.
   k. Instrument air dew point high alarm: Functions when the line pressure dew point rises above -30 degrees C (-22 degrees F) at 380 kPa (55 psig).

D. Alarm Functions:

1. compressed air alarms: Pressure alarms: Functions when pressure in branch drops below 275 kPa (40 psig), ±14 kPa (±2 psig) or increases above 414 kPa (60 psig), ±14 kPa (±2 psig) set points; operated by pressure switches or transmitters.
2. Vacuum alarms: Low vacuum alarm: Functions when vacuum in branch drops below 40 kPa (12 inches Hg); operated by vacuum switch.
3. Vacuum alarms:
   a. Low vacuum alarm: Function when system vacuum upstream of main shutoff valve drops below 40 kPa (12 inches Hg); operated by vacuum switch.
   b. Filter differential pressure/back pressure alarm: Functions when discharge oil filter differential rises to set level, or when back pressure is sensed; receives signal from pump control panel.
   c. Laboratory vacuum pump malfunction.

E. Alarm Panels:

1. General: Modular design, easily serviced and maintained; alarms operate on alternating current (AC) low voltage control circuit; provide required number of transformers for efficient functioning of complete system. Alarm panels shall be integral units, reporting compressed air and vacuum services, as required.
2. Box: Flush mounted, sectional or one piece, corrosion resistant. Size box to accommodate required number of service functions for each location, and for one audible signal in each box. Anchor box securely. Provide spare capacity to accommodate 50 percent of the number of provided alarm points.
3. Cover plate: Designed to accommodate required number of signals, visual and audible, for each location, and containing adequate operating instructions within the operator's view. Bezel shall be extruded aluminum, chromium plated metal, or plastic. Secure to the box with chromium plated or stainless steel countersunk screws.
4. Service indicator lights: Red translucent plastic or LED with proper service identification inscribed thereon. Number of lights and service instruction shall be as required for each location. Provide each panel with a green test button of the same material, inscribed with "PUSH TO TEST" or similar message.
5. Audible signal: Provide one in each alarm panel and connect electrically with all service indicator light functions.

6. Controls:
   a. Visual signal: When the condition occurs which any individual service indicator light is to report, button for particular service shall give a lighted visual signal which cannot be canceled until such condition is corrected.
   b. Audible signal: Alarm shall give an audible signal upon circuit energization of any visual signal. Audible signal shall be continuous until silenced by pushing a button. This shall cancel and reset audible only, and not affect the visual signal. After silencing, subsequent alarms shall reactivate the audible alarm.
   c. Signal tester: Test button or separate normal light shall be continuously lighted to indicate electrical circuit serving each individual alarm is energized. Pushing test button shall temporarily activate all visual signals and sound audible signal, thereby providing desired indications of status of system.

2.6 PRESSURE SWITCHES

A. General purpose, contact or mercury type, allowing both high and low pressure set points, with contact type provided with a protective dust cover; adjustable range; switches activate when indicated by alarm requirements. Use one orifice nipple (or DISS demand check valve) for each sensor or pressure switch.

2.7 AIR COMPRESSOR SYSTEMS

A. System Design: The laboratory air system shall be of a modular base mounted design consisting of duplex compressor, dryer/control, and an air receiver. Each unit shall be fully compliant with the latest edition of NFPA 99.

B. Compressors: Continuous duty rated “oil-less” type with permanently lubricated, sealed bearings. Single stage design, air cooled, reciprocating type with corrosion resistant reed type valves with stainless steel reeds. Both the compression rings and rider rings shall be made from a long life, fluororesin material designed for continuous duty operation. The crankshaft shall be constructed of a durable nodular graphite cast iron and designed to be fully supported on both ends by heavy duty ball bearings permanently lubricated and sealed. The crankcase shall be constructed of gray cast iron. Maximum heat dissipation shall be achieved through cast aluminum alloy cylinders treated for optimum corrosion and wear resistance. Cylinder sleeves shall not be required. Additionally, heat transmission from the piston

wall to the piston pin needle bearing shall be minimized by an insulated "heat cut" piston pin. The connecting rod shall be of a one piece design for maximum reliability. Bio-based materials shall be utilized when possible.

C. Compressor Drive and Motor: V-belt driven through a combination flywheel/sheave and steel motor sheave with tapered bushing and protected by an OSHA approved, totally enclosed belt guard. Belt tensioning shall be achieved by a pivoting motor mounting base that is fully adjustable through twin adjusting screws. The motor shall be a NEMA rated, open-drip-proof, 1800 RPM, with 1.15 service factor suitable for 208/230/460V electrical service, a specified in Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.

D. Intake Piping: Provide a pre-piped intake manifold with one inlet air filter with threaded opening for remote intake connection. Isolate filter housing from the intake manifold with a braided 304 stainless steel flex connector.

E. Discharge Piping: Provide an integral air cooled aftercooler designed for a maximum approach temperature of -11 degrees C (12 degrees F) complete with moisture separator and timed automatic solenoid drain valve with a manual drain value by-pass. Provide each cylinder head with a pre-wired high discharge air temperature shutdown switch. Include a flex connector, safety relief valve, and check valve. The compressor discharge line the piping shall be of ASTM B819 copper tubing, brass, and/or stainless steel. The discharge flex connector shall be braided 304 stainless steel, brass or bronze.

F. Isolation System: Isolate the compressor and monitor from the main compressor module base by means of a four point, heavy duty, spring isolation system for a minimum of 95 percent isolation efficiency.

G. Dryer/Control: The dryer/control shall include a NEMA 12, U.L. labeled control system, duplexed desiccant drying system, duplexed final line filters, duplexed final line regulators, and combination dew point/CO monitor. All of the above shall be pre-wired and pre-piped in accordance with NFPA 99 and include valving to allow complete air receiver by-pass, as well as air sampling port.

H. Dryer: Size each desiccant dryer for the peak calculated demand and capable of producing -12 degrees C (10 degrees F) pressure dew point. Dryer purge flow shall be minimized through an on-demand purge saving control system. Include a mounted prefilter rated for 0.01 micron with

automatic drain and element change indicator on the inlet of each dryer.

I. Control System: Mounted and pre-wired control system shall be NEMA 12 and U.L. labeled. This control system shall provide automatic lead/lag sequencing with circuit breaker disconnects for each compressor with external operators, one non-fused main disconnect with external operators, full voltage motor magnetic starters with overload protection, redundant 120V control circuit transformers, visual and audible reserve unit alarm with isolated contacts for remote alarm, hand-off-auto (HOA) lighted selector switches, automatic alternation of both compressors with provisions for simultaneous operation if required, automatic activation of reserve unit if required, visual alarm indication for high discharge air temperature shutdown with isolated contacts for remote alarm, and duplexed run time hour meters.

J. Final Line Filters and Regulators: Fully duplexed final line filters rated for 0.01 micron with element change indicators shall be factory mounted and pre-piped, along with duplexed factory mounted and pre-piped final line regulators and duplex safety relief valves.

K. Dew Point Hygrometer/CO Monitor: Mounted, pre-piped and wired, combination dew point hygrometer/CO monitor shall be of the ceramic type with integral chemical type CO sensor. System accuracy shall be $\pm$ 1 degree C (2 degrees F) for dew point and 2 mg/L (2 PPM) (at 10 PPM) for carbon monoxide. Dew point alarm shall be factory set at 4 degrees C (40 degrees F) per NFPA 99, and the CO alarm shall be factory set at 10 mg/L (10 PPM). Both set points shall be field adjustable.

L. Air Receiver: Vertical air receiver, galvanized, ASME Coded, National Board Certified, rated for minimum 1035 kPa (150 psig) design pressure and includes a sight gauge glass as well as a timed automatic solenoid drain valve. Provide three valve bypass on supply.

M. Example of an acceptable product and manufacturer: Beacon Medical Products “Lifeline Medical Air Systems”.

2.8 PRESSURE REGULATORS

A. For 690 kPa (100 psig) regulator, provide duplex in parallel, valve for maintenance shut-down without service interruption. For additional pressures, locate regulators remote from compressor near point of use, and provide with isolation valves and valve bypass.

1. For systems 5 L/s (10 SCFM) and below: Brass or bronze body and trim, reduced pressure range 170 to 850 kPa (25 to 123 psig)

adjustable, spring type, diaphragm operated, relieving. Delivered pressure shall vary not more than 1.0 kPa (0.15 psig) for each 10 kPa (1.5 psig) variation in inlet pressure.

2.9 EMERGENCY LOW PRESSURE OXYGEN INLET

A. The Low Pressure Emergency Oxygen Inlet provides an inlet for connecting a temporary auxiliary source of oxygen to the oxygen pipeline system for emergency or maintenance situations per NFPA 99.

B. The inlet consist of a 25 mm (1 inch) ball valve, pressure gauge and a 15 mm x 25 mm (1/2 inch x 1 inch) NPTF connection housed in a weather tight enclosure. The enclosure is labeled "Emergency Low Pressure Gaseous Oxygen Inlet", and includes a padlock staple to prevent tampering or unauthorized access. The enclosure is suitable for recess mounting on the exterior of the building being served. The enclosure is 1.9 mm (14 gauge), cold rolled steel with a primer coat of paint. The Emergency Oxygen Inlet is connected at a point downstream of the main supply line shutoff valve.

C. Check valves are provided for installation in the emergency supply line and in the main supply line between the main line shutoff valve and the emergency supply line connection per by NFPA 99. Check valves have a cast bronze body and straight through design for minimum pressure drop.

D. The check valves for sizes under 75 mm (3 inch) are soft seated, bubble tight, self-aligning, and spring loaded, and ball type check valves. 75 mm (3 inch) check valves are hard seated, spring loaded, self-aligning ball type checks with cone seats (3 inch valves may not be "bubble tight"). Check valves shall be fast acting type.

E. A relief valve is provided for installation in the emergency supply line per NFPA 99. The relief valve has a brass body, single seat design, and is cleaned for oxygen use. It automatically reseats to provide a "bubble tight" seal after discharging excess gas. Pre-set at 520 kPa (75 psig).

PART 3 - EXECUTION

3.1 INSTALLATION

A. In accordance with NFPA 99. Run buried oxygen piping in PVC protective pipe for entire length including enclosure of fittings and changes of direction.

B. Install cast escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

C. Open ends of tube shall be capped or plugged at all times or otherwise sealed until final assembly to prevent infiltration of any foreign matter.

D. Cut piping square and accurately with a tube cutter (sawing is prohibited) to measurements determined at place of installation. Ream tube to remove burrs, being careful not to expand tube, and so no chips of copper remain in the tube. Work into place without springing or forcing. Bottom tube in socket so there are no gaps between tube and fitting. Exercise care in handling equipment and tools used in cutting or reaming of tube to prevent oil or grease being introduced into tubing. Where contamination has occurred, material is no longer suitable for oxygen service.

E. Spacing of hangers: NFPA 99.

F. Rigidly support valves and other equipment to prevent strain on tube or joints.

G. While being brazed, joints shall be continuously purged with oil free nitrogen. The flow of purged gas shall be maintained until joint is cool to touch.

H. Do not bend tubing. Use fittings.

I. Support ceiling column assembly from heavy sub-mounting castings furnished with the unit as part of roughing-in. Anchor with 15 mm (1/2-inch) diameter bolts attached to angle iron frame supported from structural ceiling, unless otherwise indicated.

J. Provide two 25 mm (1 inch) minimum conduits from ceiling column assembly to adjacent corridor, one for mass spectrometer tubing and wiring and one for monitor wiring, for connection to signal cabling network.

K. Install pressure switches, transmitter and gauges to be easily accessed, and provide access panel where installed above plaster ceiling. Install pressure switch and sensors with orifice nipple between the pipe line and switches/sensors.

L. Apply pipe labeling during installation process and not after installation is completed. Size of legend letters shall be in accordance with ASME A13.1.

M. Pipe compressor intake to a source of clean ambient air as indicated in NFPA 99.

N. After initial leakage testing is completed, allow piping to remain pressurized with testing gas until testing agency performs final tests.

O. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoked partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING, with intumescent materials only. Completely fill and seal clearances between raceways and openings with the fire stopping material.
2. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.

P. Provide 40 mm (1-1/2 inch) diameter line pressure gage downstream of zone valve in cabinets.

Q. Provide zone valves in cabinets where indicated and outside each Operating Room and a minimum one zone valve assembly for each 18 outlet set.

3.2 STARTUP AND TESTING

A. Initial Tests: Blow down and high and low pressure leakage tests as required by NFPA 99 with documentation.

B. Laboratory and/or healthcare testing agency shall perform the following:

1. Perform and document all cross connection tests, labeling verification, supply system operation, and valve and alarm operation tests as required by, and in accordance with NFPA 99 and the procedures set forth in pre-qualification documentation.
2. Verify that the systems, as installed, meet or exceed the requirements of NFPA 99, this specification, and that the systems operate as required.
3. Piping purge test: For each positive pressure gas system, verify cleanliness of piping system. Filter a minimum of 1000 liters (35 cubic feet) of gas through a clean white 0.45 micron filter at a minimum velocity of 100 liters per minute (3.5 SCFM). Filter shall show no discoloration, and shall accrue no more than 0.1 mg (0.0000035 ounces) of matter. Test each zone at the outlet most remote from the source. Perform test with the use of an inert gas as described in CGA P-9.
4. Piping purity test: For each positive pressure system, verify purity of piping system. Test each zone at the most remote outlet for dew

point, carbon monoxide, total hydrocarbons (as methane), and halogenated hydrocarbons, and compare with source gas. The two tests shall in no case exceed variation as specified in paragraph, "Maximum Allowable Variation". Perform test with the use of an inert gas as described in CGA P-9.

5. Outlet and inlet flow test:
   a. Test all outlets for flow. Perform test with the use of an inert gas as described in CGA P-9.
   b. air outlets shall deliver 100 Lpm (3.5 SCFM) with a pressure drop of no more than 34 kPa (5 psig), and static pressure of 345 kPa (50 psig).
6. Source Contamination Test: Analyze each pressure gas source for concentration of contaminants, by volume. Take samples for air system test at the intake and at a point immediately downstream of the final filter outlet. The compared tests shall in no case exceed variation as specified in paragraph "Maximum Allowable Variation". Allowable concentrations are below the following:

Dew point, air	4 degrees C (40 degrees F) pressure dew point at 690 kPa (100 psig)
Carbon monoxide, air	10 mg/L (ppm)
Carbon dioxide, air	500 mg/L (ppm)
Gaseous hydrocarbons as methane, air	25 mg/L (ppm)
Halogenated hydrocarbons, air	2 mg/L (ppm)

7. Analysis Test:
   a. Analyze each pressure gas source and outlet for concentration of gas, by volume.
   b. Make analysis with instruments designed to measure the specific gas dispensed.
   c. Allowable concentrations are within the following:
      1) Laboratory air 19.5 percent to 23.5 percent oxygen.

Medical air	19.5% to 23.5% oxygen
Carbon Dioxide	99% plus carbon dioxide

//2) [add name of special gas and analysis test criteria here]//

8. Maximum Allowable Variation: Between comparative test results required are as follows:

Dew point	2 degrees C (35 degrees F)
Carbon monoxide	2 mg/L (ppm)
Total hydrocarbons as methane	1 mg/L (ppm)
Halogenated hydrocarbons	2 mg/L (ppm)

3.3 CONNECTION TO EXISTING LABORATORY GAS SYSTEM:

A. Contactor shall test the existing system for hydrocarbons, dew point, etc. per NFPA 99. If problems are present, the COR would notify the facility of the results. The facility would then make the necessary repairs and/or maintenance prior to connecting to new system.

B. Install shut-off valve at the connection of new line to existing line.

C. Time for shutdown of the existing laboratory and healthcare system shall be coordinated at least 10 work days prior to shutdown with the COR and VA Medical Center.

D. Shut off all oxygen zone valves and gas riser valves if the section to be connected cannot be totally isolated from the remainder of the system.

E. Prior to any work being done, check the new pipeline for particulate or other forms of contamination per NFPA 99.

F. Ensure that the correct type of pipe tubing and fittings are being used.

G. Make a spot check of the existing pipelines in the facility to determine the level of cleanness present.

H. Reduce the pressure to zero and make the tie-in as quickly as possible. A nitrogen purge is not required since this would require another opening in the pipe.

I. After the tie-in is made and allowed to cool, slowly bleed the source gas back into the pipeline. Test the work area for leaks with soapy water and repair any leaks.

J. After all leaks, if any, are repaired and the line is fully recharged, perform blow down and testing. Open the zone that is closest to the main to the system, access the closest outlet to the work, and blow the main through the outlet. After the outlet blows clear into a white cloth, make an additional check at a zone most distant from the work. Perform all required NFPA 99 tests after connection.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct VA Personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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